Automated Frequency Coordination (AFC) system

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As mentioned in Nokia's Comments,[1] the Automated Frequency Coordination (AFC) system can play a central role in protecting fixed links in the U-NI-5 and U-NII-7 spectrum bands. We hereby provide some initial details about the AFC for the Commission's consideration. Nokia continues to recommend that the Commission and/or a group of stakeholders, including the fixed links vendors and users, define the requirements of the AFC system in detail and that the AFC system is tested before it is commercially deployed.

The AFC's two main design objectives are as follows:

(1) Guaranteeing much needed protection to existing and potentially future incumbent usage in the form of Fixed Link (FL) wireless systems that provide critical backhaul service to commercial cellular networks – specifically in the 5.925-6.425 GHz (U-NII-5) and 6.525-6.875 GHz (U-NII-7) bands; and
(2) Providing rapid access to U-NII-5, UN-II-7 spectrum for new shared indoor and outdoor use without requiring tedious manual coordination with existing incumbent systems.

To achieve these objectives, the AFC needs full knowledge of the (a) legacy fixed links that need protection and (b) at a minimum, geo-location of new entities interested in using the spectrum band. We envision that information on existing and any future FL systems will be maintained in a continuously updated FL database (FLDB) that AFC systems can periodically download. The database entries record parameters of FL systems – specifically characteristics of TRXs in the FL links such as geo-location, antenna height, antenna characteristics (e.g., gain, sectorization), maximum power and frequencies/channels (i.e. portions of U-NII band) used. The Commission's ULS database can be such an FLDB as long as the information is accurate, up-to-date and covers the FL parameters mentioned above.

To meet the first objective of protecting incumbents, the AFC relies on a concept called Fixed Link Protection Zone (FLPZ) -- which is a spatial area characterizing the area of operation of the fixed links over which receivers in the fixed link endpoints need to be protected. Each FLPZ also has associated with it a set ***FR*** of frequencies/channels that FL system uses. Figure 1, below, illustrates the concepts of FLPZ and set ***FR.*** The FLPZ can be established using: (a) in-field measurements; (b) as a specification by the incumbent owner, in the form of a closed polygon over which the FL needs protection; or (c) by using a coverage estimator – a computational procedure that leverages propagation models and FL TRX characteristics (such as location,

[1] Comments of Nokia, ET Docket No. 18-295, GN Docket No. 17-183 (filed Feb. 15, 2019).

antenna height, characteristics and transmit power). The estimated coverage can be further increased with an additional spatial area called protection buffer to obtain final FLPZ estimate. In option (a) and (b), the FLPZ can be stored in the FLDB entry where as in option (c), the AFC will compute it.

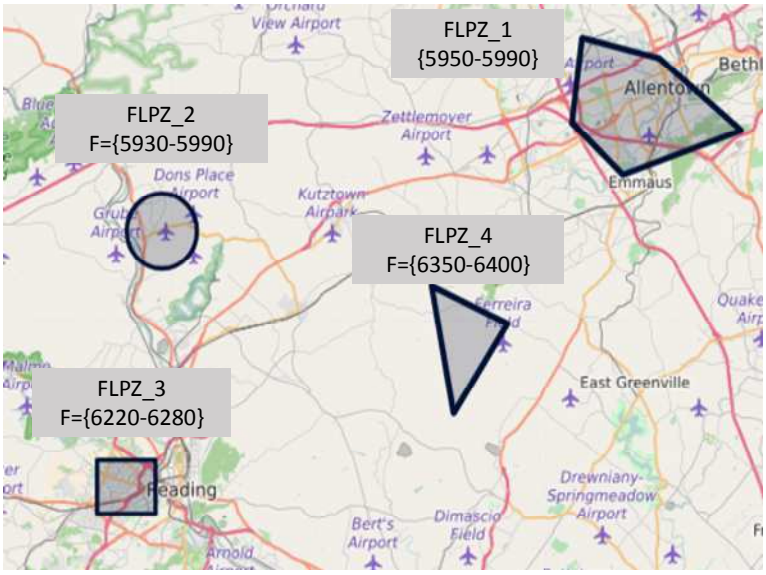

Figure 1: Exemplary Fixed Link Protection Zone (FLPZ) and associated Frequency in use set F

Enforcement of FLPZ

The AFC guarantees protection of FL links by ensuring that no unlicensed systems whose location falls inside FLPZ is granted the same channels that FL systems use. The concept of operation for enforcing such protection is as follows:

(1) When an unlicensed system boots and needs to configure a radio channel in U-NII-5/7 band, it contacts the AFC system and presents its geo-location L = (Latitude, Longitude).

(2) The AFC consults its FLPZ database to find the set *FZ* of all FLPZ polygons in which the candidate location L falls. The set ***FR_ALL*** containing all frequencies associated with these FLPZs represents all frequencies in use by incumbent FLs and, therefore, blocked for unlicensed use.

(3) The AFC forwards the set FR_ALL to the unlicensed system which can then select a least used channel in the U-NII-5/7 band that does not belong to the set FR_ALL.

In this way, the AFC eliminates any co-channel use of frequencies used in FL systems and segregates the FLs and new unlicensed systems into independent (orthogonal) frequencies and eliminates the interference.

The AFC can facilitate more aggressive sharing of channels used by FL systems by carefully allocating transmit power to unlicensed systems such that their aggregate interference to FL links is below a threshold. Such fine-grain sharing may be useful especially for indoor systems. However, it does lead to additional complexity -- AFC must actively track all unlicensed Access Points and actively control them to adjust their transmit power to maintain aggregate interference below a certain threshold.

In its basic form, the AFC's role is limited to protecting FL systems and it does not concern itself with how unlicensed systems – owned by different entities in a given region overlapping FL systems – share the spectrum. This makes AFC implementation rather simple and consistent with unlicensed access mode envisioned for U-NII-5 and U-NII-7 bands -- as it does not need to track a large number of unlicensed systems that may use the U-NII bands.

Implementing AFC

We consider two options for implementation of AFC system:

(1) Cloud resident AFC Server: Here, the AFC is implemented as a network resident service that can be accessed by individual unlicensed access points (APs) (e.g., in homes) or a proxy of a network of APs (e.g., deployed in large venues, enterprise networks, or networks of mobile or cable network operators (MNOs, MSOs). This model allows multiple AFC servers to be present in the ecosystem and all of them offer the same basic service of providing a list of safe channels. The AFC servers can collaborate to better optimize sharing and offer further value-added services: (1) services to unlicensed systems to help them optimize their performance; and (2) services to incumbents that enable interference reporting and revisions of FLPZs.

(2) AFC as Element Management System (EMS) in Operation Support Systems (OSS): In this instantiation, the unlicensed systems are always deployed in a managed scenario such as APs provided by cable or fiber operators for home, office and enterprise deployments. The organic deployment wherein APs are standalone (e.g., APs bought at a retail store and deployed in-home) is not supported in this scenario. The AFC server is implemented as an EMS function that obtains the FLDB and provides available channels to all APs under its control. Clearly, in this case, the AFC can also deconflict the APs into independent channels to optimize their capacity.

Since AFC is envisioned to be part of a private network, each AFC is standalone and inter-AFC communication is not envisioned. This also requires that the FLDB contain the FLPZ definitions to ensure all AFCs use the same FLPZ to guarantee FL protection. This however requires a third party (such as FCC or industry body) to register FL systems and compute FLPZs.